INSURANCE INSTITUTE
FOR HIGHWAY SAFETY

July 2, 2004

The Honorable Jeffrey W. Runge, M.D.
Administrator
National Highway Traffic Safety Administration
400 Seventh Street, S.W.
Washington, D.C. 20590

Request for Comments; Federal Motor Vehicle Safety Standards; Occupant Crash Protection; Docket No. NHTSA 2003-15715

Dear Dr. Runge:

The National Highway Traffic Safety Administration (NHTSA) has asked for comments on a possible frontal offset crash test requirement. The Insurance Institute for Highway Safety is pleased the agency is taking this important step toward improving frontal crash protection for motor vehicle occupants. However, we are concerned the agency has greatly underestimated the benefits of good frontal offset crash protection by relying too heavily on dummy test results while ignoring real-world evidence concerning the benefits of such protection. In addition, NHTSA's conclusion that the offset test poses potential risk in making vehicles more aggressive relies on a small number of crash tests that essentially are meaningless in estimating the relationship between vehicle stiffness and aggressivity. The Institute offers the following comments in the hope of clarifying and resolving these issues so the agency can move forward with rulemaking to require good frontal offset crash protection in all passenger vehicles.

Underestimated Benefits of Improved Frontal Offset Crash Protection
NHTSA concludes that the primary benefit of designing vehicles to perform well in a high-speed offset test is a reduction in Abbreviated Injury Scale (AIS) 2+ lower extremity injuries, claiming that "dummy head, chest, and femur injury measures were typically meeting the injury criteria in the fixed offset deformable barrier crash tests, so no additional benefits were projected in these areas beyond those already achieved through the FMVSS 208." This conclusion is illogical and inconsistent with evidence from the real world.

It is illogical because the conclusion rests on the simplistic notion that the injury measures recorded by test dummies are the only indicators as to how human occupants might fare in a similar crash. As a result, NHTSA interprets its frontal offset tests as demonstrating that only lower extremities would benefit from requiring good frontal offset crash protection because the lower legs are the only parts of the dummy that sustain high forces and accelerations. However, common sense tells a researcher that human occupants are better protected against a variety of serious head and chest injuries in an occupant compartment that maintains its integrity during a crash

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than in one that collapses. This must be true, even if the measures from a single-size dummy do not exceed injury assessment reference values.

In the analysis of its frontal offset crash tests, NHTSA ignored important information about occupant compartment integrity. The frontal offset test was developed specifically to assess occupant compartment stability, that is, to determine whether designs can protect against the kinds of occupant compartment intrusion that have been implicated in the serious and fatal injuries of restrained occupants in real-world crashes (Hobbs, 1995; Lowne, 1994). If a test is designed to force improvements in occupant compartment strength, it is illogical to ignore signs of weakness in this aspect of design in the test results. Yet this is what the agency has done by basing its analysis solely on the dummy injury measures in its tests.

The first prerequisite for an effective federal standard concerning frontal offset crash protection is that it must address the issue of occupant compartment integrity simply and directly. Good dummy injury measures, based on a test with a single-size dummy in one seating position, indicates good frontal crash protection only *if* the occupant compartment is not significantly damaged. If the compartment is significantly damaged, dummy measures below injury assessment reference values offer no assurance of effective protection for the range of occupants who sit in different positions and may have different crash kinematics.

NHTSA’s analysis also is inconsistent with real-world crash experience, which increasingly shows the benefits of improved frontal offset test performance for serious and fatal injuries. A recent Scandinavian study evaluated cars with different levels of performance in EuroNCAP’s consumer evaluation program, which includes a frontal offset crash test (Lie and Tingvall, 2002). The researchers reported that cars with better performance in EuroNCAP had much lower rates of serious injury than cars with worse performance. In a more recent U.S. study using different analytic methods, the Institute found that drivers of vehicles with good frontal offset test ratings involved in fatal head-on crashes with poor-rated vehicles were 74 percent less likely to be the fatally injured driver. Drivers of acceptable/ marginal-rated vehicles were 45 percent less likely to die in their head-on collisions with poor-rated vehicles (Farmer, in press).

These real-world results show the important benefits to the public of improvements in frontal offset crash protection. As the Institute and other consumer information organizations now focus their attention toward other design improvements such as side impact protection, it is important that NHTSA ensure continuation of these improvements by establishing a federal standard. Such a standard also would ensure that all vehicle types, including those not selected for testing by consumer organizations, are designed with state-of-the-art frontal crash protection. However, this standard cannot be effective without specifically addressing occupant compartment integrity, as already discussed. The primary factor that has affected the Institute's ratings over the years, and the factor that has improved and driven the real-world fatality findings stated above, is the ability of a vehicle's structure to reduce and limit damage to the occupant compartment.

Overstated Risk of Increased Vehicle Aggressivity from Improved Frontal Offset Crash Protection

NHTSA's concern that improved frontal offset crash protection could lead to greater incompatibility in vehicle-to-vehicle crashes rests on flawed logic regarding the causes and correction of poor performance. The agency assumes vehicles will become stiffer because of the frontal offset test. In fact, research suggests no significant correlation between vehicle stiffness and frontal offset test performance. A recent study by the Institute found that stiffness, as determined from NCAP tests, was unrelated to the Institute's structural ratings (Nolan and Lund, 2001). Although some vehicles with improved frontal offset test performance were "stiffer" than their predecessor models, the increased stiffness typically was evident only after about 50 cm of vehicle deformation, when the crash deformation had neared the occupant compartment. This increased stiffness is necessary and appropriate if the overall safety of the motor vehicle fleet is to improve. It is counterproductive in terms of safety to argue that one vehicle's occupant compartment must collapse, and thus not protect its own occupants, in order to be less aggressive in collisions with other vehicles. A more productive strategy is to require all vehicles to have occupant compartments with sufficient strength to maintain their integrity in collisions with other passenger vehicles.

NHTSA's analysis also misses the fact that poor offset crash test performance occurs in part because a vehicle's front structure already is too stiff. Many poor-performing vehicles in the Institute's offset test had major occupant compartment intrusion, while significant portions of their front energy-absorbing structures remained intact. A good example is the 1997 Pontiac Trans Sport. In this test, the engine cradle was largely undamaged, and the front longitudinal was not completely crushed (Figure 1).

The assumption that manufacturers simply make vehicle front ends stiffer to perform well in the offset test is incorrect. In many cases, manufacturers strategically *weaken* the front structure and *strengthen* the occupant compartment to ensure that the occupant compartment has sufficient integrity to force the frontal crush zone to absorb crash energy. Balancing of compartment and crush zone stiffness is an essential element of good crashworthiness and is promoted by offset testing.

Figure 1
1997 Pontiac Trans Sport after Institute 64 km/h 40 Percent Frontal Offset Test

It is important to note that the real-world data are in accordance with this logic, and they contradict NHTSA’s concerns. As noted earlier, the Institute recently completed a study documenting the improved survival odds for drivers of good-rated vehicles compared with poor-rated ones when these vehicles collide head on (Farmer, in press). Using the same database as in this study, the Institute conducted another analysis to determine whether the better performance of the good-rated vehicles might contribute to greater aggressivity in crashes with other vehicles. For this analysis, all frontal crashes of Institute-rated vehicles that involved another vehicle were examined. Driver fatality rates were calculated for both the Institute-rated vehicle, as reported in the initial study, and for the other vehicle by dividing the numbers of fatalities by the number of Institute-rated vehicles registered during the years covered.

Although the relationships across all rating levels were not uniform, a remarkably consistent pattern across vehicle types was that driver fatality rates were higher in both the rated vehicle and other vehicle when the rated vehicle had a poor rating than when it had a good rating. Even when looking only at structural ratings, cars, minivans, and sport utility vehicles (SUVs) with good evaluations had lower opposing vehicle driver fatality rates than those with poor ratings. Only among pickups was there a slight reversal of the finding. This pattern contradicts NHTSA’s concern that improved frontal offset test performance might be leading to increased aggressivity in crashes with other vehicles. Instead, it supports the structural argument noted above that the kinds of design changes required for good frontal offset test performance also can reduce aggressivity in crashes with other vehicles. Details of the statistical analysis and results are provided in the Appendix.

Aggressivity Concerns Rely on Ill-Conceived and Inadequately Analyzed Crash Tests

Against the logical and empirical evidence cited above, NHTSA offers results of a small series of crash tests in which a vehicle with improved frontal offset test performance strikes a common target vehicle, a 1997 Honda Accord, in a high-speed 30-degree oblique angle frontal offset test. Results are compared with those from a similar test involving the predecessor models of these redesigned vehicles also striking a Honda Accord. The primary dependent variable in these tests is injury risk to the driver dummy seated in the Honda Accord before and after performance improvements to the striking vehicle. In theory, such tests could isolate the effects on driver dummy injury risk of changes in vehicle stiffness associated with improved crash test performance. In fact, however, most of these tests confounded changes in vehicle stiffness with changes in other important vehicle characteristics.

No attempt was made in these tests to isolate the unique effects of front-end stiffness from other vehicle factors that also changed during vehicle redesign. For example, one pair of tests involved the Chevrolet TrailBlazer, which replaced the Chevrolet Blazer in the U.S. market. The TrailBlazer had somewhat improved performance in the Institute's offset test, although its structural integrity still was considered only acceptable. NHTSA assumed the TrailBlazer's moderate improvement was achieved by increasing its front-end stiffness, and tests with the Honda Accord were intended to assess how much more aggressive this made the TrailBlazer compared with the Blazer. Several injury measures indeed were higher for the driver dummy in the Accord, appearing to support the agency's concerns about increased stiffness. However, according to NHTSA's reports the Trailblazer tested not only was *stiffer* than the Blazer but also 226 kg *heavier*, and the bottom edges of its longitudinal frame rails were 44 mm *higher*. Both of these vehicle factors could account for any differences in the TrailBlazer's aggressivity in a collision with another vehicle. Institute research has shown, for example, that increasing a vehicle's ride height can make it far more aggressive as a striking vehicle in side impacts than increasing its front-end stiffness (Nolan et al., 1999). This finding is pertinent here because NHTSA's 30-degree frontal oblique test is more characteristic of a side impact test with respect to the time when many of the injury measures peaked for the driver dummy in the Accord. It is unclear why NHTSA chose to ignore these confounding differences, which could have been controlled easily in these paired tests, because the end result is that any differences between the Blazer and TrailBlazer tests cannot be attributed to stiffness differences or any other single vehicle factor.

This criticism applies to some extent to all the paired tests because in every case NHTSA failed to control for the mass and/or ride height of the striking vehicle. Compared with its predecessor model, the redesigned Mitsubishi Montero Sport had similar mass, but its longitudinal frame rails were 54 mm higher. The disparity in ride height was further exaggerated by the fact that, according to NHTSA's test reports, the frame rails of the Accord were 29 mm lower in the test with the redesigned Montero Sport than in the test with the earlier model. At a very minimum, the mass and ride height of the Accord should have been maintained. In addition, the selection of the Montero Sport as a striking vehicle for this study is unclear because the agency provides no evidence that the redesigned Montero Sport actually was stiffer.

It is instructive to consider NHTSA's tests of the 1996 Toyota Avalon versus the redesigned 2000 Toyota Avalon. Again the target vehicle was a Honda Accord, and the dependent variable was the difference in injury risk to the Accord driver dummy. The 1996 and 2000 Avalons were similar in mass, but the structural height of the 2000 Avalon was about 58 mm lower than that of the 1996 Avalon. The driver dummy in the Accord exhibited lower injury risk when struck by the redesigned Avalon compared with the earlier model. Thus, when mass remained the same and front structural elements were lowered, improved frontal offset test performance reduced injury risk to the driver dummy. It is troubling that NHTSA did not discuss these results in its request for comments. Even though the Avalon test report was not available to the public at the time, the results clearly were available to the agency and should have been considered in its discussion of the potential effects of improved frontal offset crash test performance.

This omission and other observations suggest that NHTSA researchers have not studied their test results in sufficient depth. For example, a close review of dummy kinematics from the test films of the Blazer and TrailBlazer reveals that the maximum head injury criterion (HIC) calculations for both tests corresponded with a time interval when the Accord driver dummy's head swings laterally out the driver window and contacts the striking vehicle's hood. In the Blazer test, however, the Accord dummy's head appears to first contact the top of the deformed window frame and then is partially obstructed by a large piece of the Blazer's grille and the Accord's side view mirror as it "contacts" the intruding hood (Figure 2). Regardless of the HIC magnitudes, the Accord driver dummies in *both* tests had a high risk of serious head trauma and/or fatality because their heads were unprotected against hard contacts outside the vehicle. The lower HIC experienced by the Accord driver dummy in the Blazer test simply reflects the fact that the head sustained multiple hits rather than a single hard contact against the hood.

There are other anomalies in the test results. For example, the chest compression curve for the Accord driver dummy in the TrailBlazer test looks very unusual starting at 96 ms when the dummy's head contacted the hood (Figure 3). First there is a period of rapid oscillation,

Figure 2
Accord Driver's Head Contacts Top of Deformed Side Window Frame (Orange Arrow); Accord's Side View Mirror (Blue Arrow) and Strip of Blazer's Grille (Red Arrow) Are Between the Head and Blazer's Hood

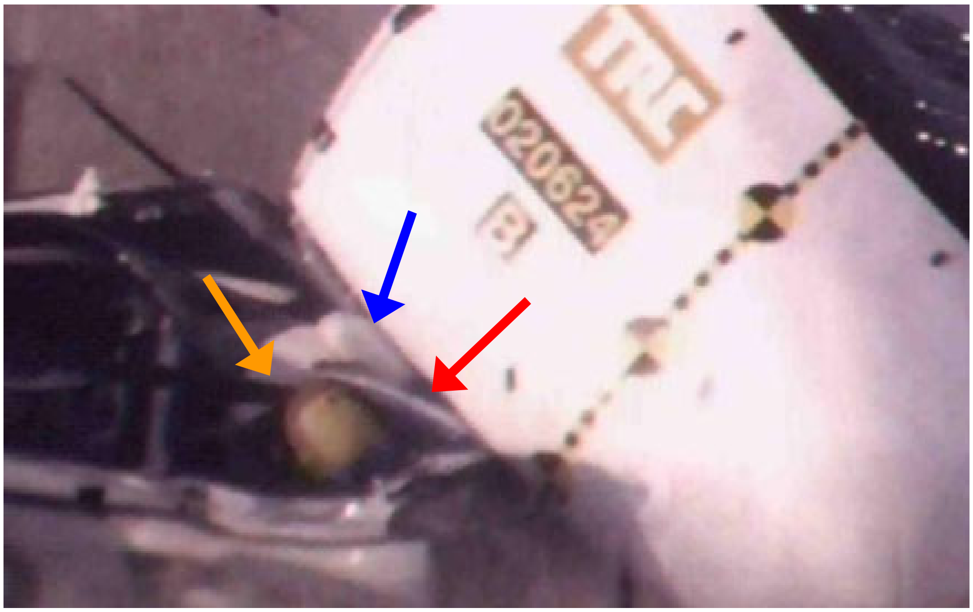
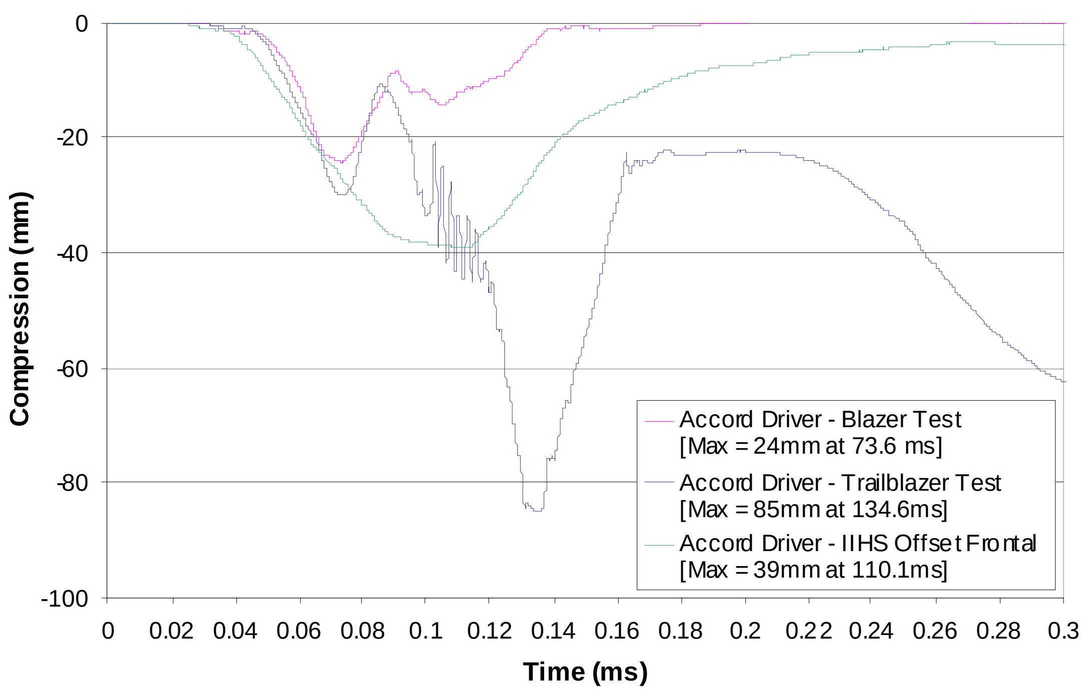


Figure 3
Honda Accord Driver Chest Compression Data



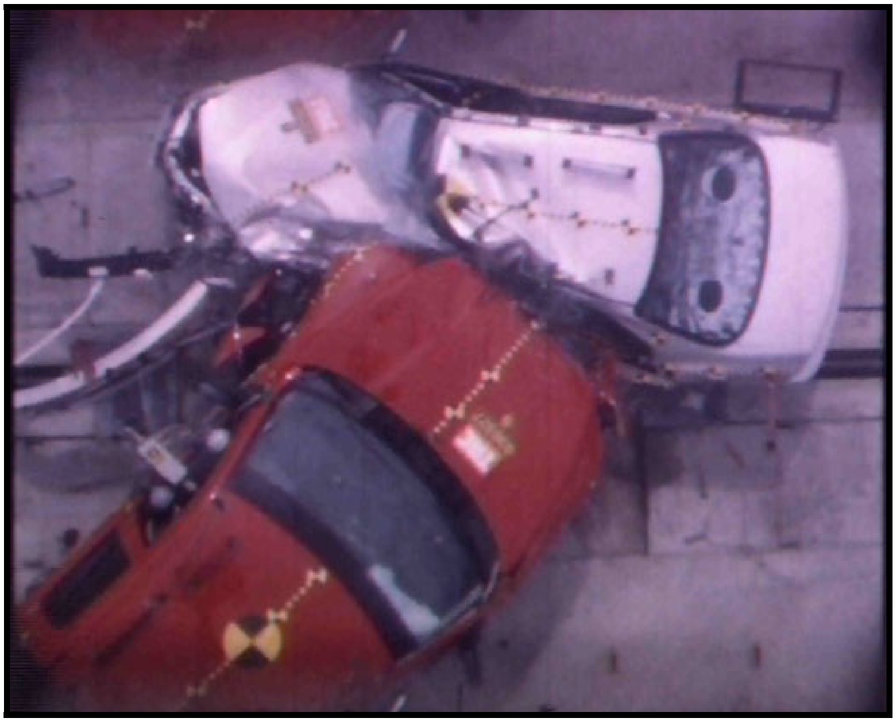
and later as the crash event is coming to an end, the compression signal continues to gradually increase, indicating a likely problem with the dummy's instrumentation. These results indicate an urgent need for senior members of the agency's research staff to thoroughly review the tests and ensure that their decisions are based on accurate characterizations of the results.

Moreover, NHTSA should have recognized that this test series was ill-suited to address the question of whether improved frontal offset crash test performance leads to greater stiffness and, hence, increased aggressivity in crashes with other vehicles. NHTSA's high-speed 30-degree frontal oblique test configuration is somewhere between a frontal impact and a side impact. Although the initial alignment specifies a 50 percent overlap of the Accord's front-end width, the angular impact configuration and the fact that both vehicles are moving means the striking vehicle in these tests does not fully engage the front energy-absorbing structure of the Accord. Nor does the striking vehicle effectively engage any of the side impact protection measures that have been implemented in doors and B-pillars in recent years. Instead, the primary loads are transmitted on the front of the left side structure, driving the left front quarter panel, wheel, and driver door rearward and inboard (Figure 4). A review of the onboard film indicates that in the tests with both the earlier models and redesigned SUVs and pickups, the Accord's steering wheel moves laterally inboard far enough to contact the right front passenger seatback before the airbag can cushion the driver dummy's forward and outboard momentum (Figure 5). As a result, the Accord dummy's head is at risk of direct contact with the hood of the striking vehicle through the side window, and the chest contacts the interior door trim. Injury measures reported by the Hybrid III frontal impact dummy are unlikely to accurately capture the full threats to a human occupant from such an impact because the loading conditions (lateral) are inconsistent with dummy design and sensor orientation.

Some of these interpretational problems could have been avoided. In fact, the Institute embarked on a similar research question a few years ago, conducting a series of 50 percent frontal offset car-to-SUV tests against a common collision partner (Meyerson and Nolan, 2001). The use of an existing test configuration ensured that a vehicle's collision management system would be available to assess the effects of differential stiffness in the event that this structure actually was engaged. In addition, the target car, a 1996 Ford Taurus, was one that had performed well in the Institute's frontal offset test.

The two SUVs chosen for the tests differed in stiffness, as determined from the force deflection curves from NHTSA's full-frontal 35 mph rigid wall tests; the Mercedes M-class had lower forces measured on the load cell wall than the comparison Isuzu Rodeo. It is noteworthy that the "softer" M-class also was a good performer in the Institute's

Figure 4
2002 Dodge Ram Striking 1997 Honda Accord



frontal offset test, whereas the Rodeo was a poor performer; thus, there was no evidence that good performance requires stiffer front ends. As in NHTSA's 30-degree frontal oblique test, the dependent variable was injury risk to the driver dummy seated in the target car, the Taurus. However, unlike NHTSA's test the striking vehicles were ballasted to the same mass to control for this vehicle factor.

In their normal configuration, the ride height of the Rodeo, as measured by the lower edge of its frame rails, was similar to that of the Taurus, and both were lower than the M-class. Tested in this configuration, the driver dummy in the Taurus exhibited higher injury risk to the head, neck, and chest when struck by the less stiff M-class. Thus, the softer M-class design did not reduce injury risk to the Taurus driver dummy compared with the stiffer Rodeo, but additional tests suggested this finding could be due to the different ride heights.

Further testing was conducted with the ride height of the Rodeo adjusted upward to match the M-class and the ride height of the M-class adjusted downward to match the Rodeo and Taurus. Results showed that when ride heights were matched, the differences between the Rodeo and M-class were very small, although dummy injury measures still tended to be slightly higher in the Taurus when struck by the less

Figure 5
Onboard View of 1997 Honda Accord Driver Struck by 2002 Dodge Ram; Steering Column Moves Inboard, Preventing Airbag from Properly Cushioning Driver's Head

stiff M-class. However, the principal finding of this test series was that the critical variable regulating injury risk in the Taurus from the striking M-class and Rodeo was not the stiffness of these SUVs but rather their ride heights. When the M-class and Rodeo were tested with their front-end structures lowered and better aligned with the height of the Taurus, the Taurus was better able to manage the forces transmitted to the driver dummy, and dummy injury measures subsequently were lower.

Another set of Institute tests was conducted to assess the nature of incompatibility between vehicles in side impacts (Nolan et al., 1999). Mercury Grand Marquis sedans were struck in the sides by pickups that varied in mass, ride height, and frontal stiffness. Again, ride height was the principal factor determining injury risk to the driver dummies in the struck Grand Marquis sedans. Mass and particularly stiffness had much smaller effects on the outcomes for the dummies in the struck vehicles.

Despite the fact that these test results have been public for several years (Meyerson and Nolan, 2001; Lund et al., 2000; Nolan et al., 1999), ride height was one of the variables NHTSA left uncontrolled in its series of tests intended to discover the possible effect of increased stiffness resulting from frontal offset crash testing. Yet higher ride height was a characteristic of at least two of the "improved" vehicles in its study. It is noteworthy that these two vehicles are the ones cited as providing evidence that improved frontal offset crash protection could lead to greater aggressivity of SUVs in impacts with cars. Clearly this conclusion is unjustified, given the failure to control for ride height. The agency should ignore these test results, which are meaningless given the study design, in deciding whether to move ahead with a standard to require minimum performance in frontal offset crashes.

Offset Test Standard Should Address Aggressivity

The Institute agrees with NHTSA about the concern for controlling aggressivity, but the issue should be separated from offset crash protection requirements. As discussed above, nothing about the frontal offset crash test suggests that its incorporation into a standard depends on addressing the issue of aggressivity.

But aggressivity or, more appropriately, the incompatibility of vehicle structures when vehicles crash into each other is an important issue in its own right. The Institute has been working with automobile manufacturers to identify potential improvements in vehicle compatibility and aggressivity. The best research shows that the immediate issue for aggressivity is improving structural interaction, and manufacturers have committed to have all vehicles' primary energy-absorbing structures overlap a car's bumper zone by September 2009 (Alliance of Automobile Manufacturers, 2003).

Regarding question 8, there is no clear evidence at this time that requiring force limits will improve vehicle fleet compatibility. Good geometrical alignment of a vehicle's energy-absorbing structure is required before any meaningful limits on maximum forces can be established. NHTSA has assumed that an offset test requirement will lead to more aggressive vehicles, but as stated earlier there are no data to support this conclusion. It is premature to set force limits without first conducting the basic research to show that such a strategy will improve vehicle compatibility.

Many metrics are proposed or under study by the research community to assess "aggressivity" including height of force, stress, homogeneity assessment, barrier force, and barrier deformation patterns. Any one of these metrics might eventually prove to be useful for assessing aggressivity and limiting incompatibility in multiple-vehicle crashes, but at present there are not sufficient data available on which to base a decision. Much of this work is planned as part of the manufacturers' voluntary compatibility commitment, and the Institute encourages NHTSA to support these activities.

Extensive effort will be required to fully understand and control the factors that influence compatibility and aggressivity, but we have strong real-world crash data indicating that vehicles designed to perform well in an offset deformable barrier test save lives and prevent injuries without compromising frontal crash partner protection. NHTSA should not delay the implementation of an offset requirement because of unsubstantiated fears of compatibility disbenefits.

Sincerely,

Joseph M. Nolan
Vice President, Research

cc: Docket Clerk, Docket No. NHTSA 2003-15715

Attachment – Appendix

References

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Appendix
Analysis of Aggressivity in Frontal Crashes by Institute Offset Deformable Barrier Test Ratings

Information on fatal crashes involving Institute-rated vehicles was extracted from the Fatality Analysis Reporting System (FARS). Crashes were restricted to two-vehicle crashes in which the rated vehicle had a principal impact point of 11, 12, or 1 o'clock. State registration counts of rated vehicles for each model year and calendar year were extracted from the National Vehicle Population Profile (R.L. Polk & Company, 2003). Because some new models did not have a full year of on-road exposure during their initial calendar year, both registrations and crashes involving any model year concurrent with or subsequent to the calendar year were excluded.

Driver fatality rates per million vehicle registrations per year were computed by vehicle type (passenger car, passenger van (minivan), pickup truck, sport utility vehicle) and crashworthiness rating (poor, marginal, acceptable, good). Exact 95 percent confidence limits were computed assuming that the number of driver deaths follows a Poisson distribution.

Adjustments were made to fatality rates to account for differences in vehicle weight across crashworthiness rating categories. First the relationship between driver fatality rates and vehicle weight was estimated by fitting an exponential curve to the rates for all 1997-99 model passenger vehicles, broken down into 500-pound weight classes. Then the estimated driver fatality rate for a crashworthiness rating category if all categories had the same mean weight (e.g., 3,000 pounds for cars) was computed as the product of the raw rate and

$$\exp(b(3000 - w)),$$

where b was the estimated coefficient of vehicle weight from the exponential curve and w was the mean weight of vehicles in the rating category (see Figures A-1 and A-2).

Both raw and adjusted fatality rates for both rated vehicle and opposing vehicle drivers and for each vehicle rating category are listed in Table A-1 (by overall crashworthiness rating) and Table A-2 (by structural crashworthiness rating).

Reference

R.L. Polk & Company. 2003. National vehicle population profile. Southfield, MI.

Table A-1
Fatal Frontal Impacts of Institute-Rated (Overall Rating) Vehicles into Other Vehicles, 1992-2001 Models during 1993-2002

					Deaths per Million Registration-Years			
		Driver Deaths			Case Vehicle Drivers		Opposing Vehicle Drivers	
Overall Rating	Weight (pounds)	Case Vehicle	Opposing Vehicle	Registration-Years	Raw	Adjusted	Raw	Adjusted
Cars								
Poor	2,913	710	675	26,515,725	27	26	25	26
Marginal	2,958	79	101	5,599,630	14	14	18	18
Acceptable	2,899	835	954	48,605,881	17	17	20	20
Good	3,253	694	1,007	40,518,561	17	19	25	23
Minivans								
Poor	3,919	89	189	5,342,625	17	16	35	36
Marginal	3,972	98	238	8,253,977	12	12	29	29
Acceptable	4,085	14	35	1,260,336	11	11	28	27
Good	3,868	71	146	5,845,508	12	12	25	26
Pickups								
Poor	4,430	114	330	4,327,969	26	28	76	66
Marginal	3,835	76	105	2,058,094	37	36	51	54
Acceptable	3,066	47	58	1,419,441	33	30	41	57
Good	4,363	1	9	131,239	8	8	69	60
Utility Vehicles								
Poor	4,104	100	280	6,266,412	16	16	45	43
Marginal	3,673	83	262	8,065,590	10	9	32	35
Acceptable	4,140	110	433	10,120,760	11	11	43	41
Good	3,954	5	17	1,057,625	5	5	16	16
Total		3,126	4,839	175,389,373	18		28	

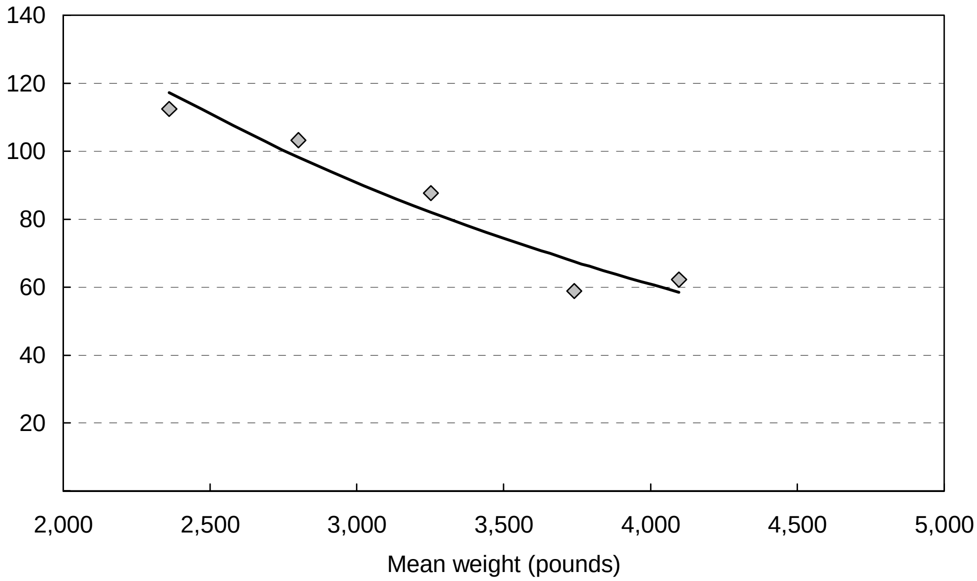
Note: Adjusted fatality rates are those estimated if each car rating group averaged 3,000 pounds, and each minivan, pickup, and utility group averaged 4,000 pounds.

Table A-2
Fatal Frontal Impacts of Institute-Rated (Structure Rating) Vehicles into Other Vehicles, 1992-2001 Models during 1993-2002

					Deaths per Million Registration-Years			
		Driver Deaths			Case Vehicle Drivers		Opposing Vehicle Drivers	
Overall Rating	Weight (pounds)	Case Vehicle	Opposing Vehicle	Registration-Years	Raw	Adjusted	Raw	Adjusted
Cars								
Poor	2,913	301	312	11,761,048	26	26	27	26
Marginal	2,958	489	438	18,868,714	26	24	23	24
Acceptable	2,899	843	1,002	52,122,214	16	16	19	20
Good	3,253	685	985	38,487,821	18	20	26	24
Minivans								
Poor	3,919	89	187	5,583,252	16	15	33	34
Marginal	3,972	5	11	366,355	14	13	30	31
Acceptable	4,085	114	272	9,390,117	12	12	29	29
Good	3,868	64	138	5,362,722	12	11	26	27
Pickups								
Poor	4,430	89	258	3,891,103	23	24	66	55
Marginal	3,835	132	218	3,506,427	38	36	62	71
Acceptable	3,066	16	17	407,974	39	34	42	63
Good	4,363	1	9	131,239	8	8	69	60
Utility Vehicles								
Poor	4,104	104	295	6,890,836	15	16	43	42
Marginal	3,673	30	103	2,930,859	10	9	35	38
Acceptable	4,140	159	578	14,907,402	11	11	39	39
Good	3,954	5	16	781,290	6	7	20	19
Total		3,126	4,839	175,389,373	18		28	

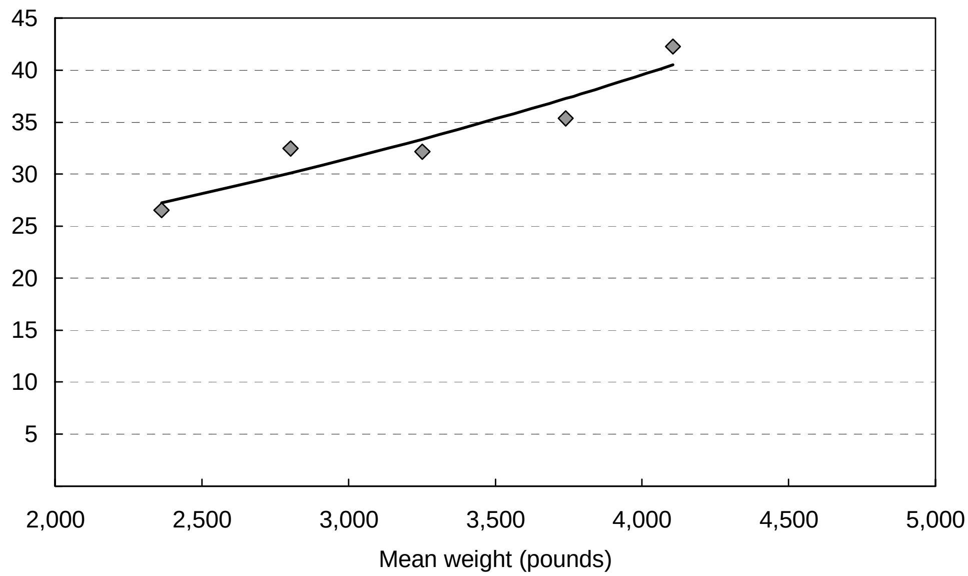
Note: Adjusted fatality rates are those estimated if each car rating group averaged 3,000 pounds, and each minivan, pickup, and utility group averaged 4,000 pounds.

Figure A-1
Driver Fatality Rates for 1997-99 Model Cars and Minivans during 2000-02



Note: Mean weight is the average weight of vehicles in each weight class: ≤2,500 pounds, 2,501-3,000 pounds, 3,001-3,500 pounds, 3,501-4,000 pounds, and >4,000 pounds; equation for the curve is $Y = \exp(5.71 – 0.00040X)$

Figure A-2
Other Vehicle Fatality Rates for 1997-99 Model Cars and Minivans during 2000-02



Note: Mean weight is the average weight of vehicles in each weight class: ≤2,500 pounds, 2,501-3,000 pounds, 3,001-3,500 pounds, 3,501-4,000 pounds, and >4,000 pounds; equation for the curve is $Y = \exp(2.77 + 0.00023X)$